MICRO SCALAR PATTERNING FOR PRINTING ULTRA FINE SOLID LINES IN FLEXOGRAPHIC PRINTING PROCESS

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To my precious Allah S.W.T,
who gave me opportunity, hope and purpose of life.
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ABSTRAK

Kajian ini tertumpu kepada pencetakan garisan halus dengan menggunakan mesin pencetak Micro-flexographic iaitu gabungan teknik pencetak flexography dan micro-contact. Flexography adalah salah satu daripada teknik cetakan menggunakan roler yang terkenal dan pantas dalam menghasilkan cetakan grafik dan peralatan elektronik ke atas pelbagai substrat. Pencetak micro-contact merupakan teknik berkos rendah yang biasa digunakan dalam penghasilan imej bersaiz micro hingga nano terutamanya dalam struktur imej garisan halus. Graphene adalah bahan bersaiz nano yang boleh digunakan sebagai dakwat pencetak yang biasa digunakan dalam pembuatan barangan elektronik bersaiz micro hingga nano. Lanthanum pula adalah bahan nadir bumi yang mempunyai potensi besar dalam bidang pencetakan. Gabungan kedua-dua teknik cetakan yang dikenali sebagai Micro-flexographic tersebut telah berjaya menghasilkan garisan halus yang terendah dari segi tebal dan jarak di antara garisan. Teknik cetakan baru ini telah mencetak imej garisan halus di bawah 10 μm di atas substrat biaxially oriented polypropylene (BOPP) dengan menggunakan dakwat graphene. Teknik cetakan Micro-flexographic telah berjaya mencetak garisan halus dengan ketebalan 2.6 μm. Kajian ini juga menerangkan pencapaian proses imprint lithography dalam menghasilkan garisan halus bersaiz micro hingga nano di bawah 10 μm. Untuk tambahan, bahan lanthanum juga telah berjaya dicetak ke atas pelbagai substrat dengan ciri-ciri kelekatan permukaan yang baik. Kajian ini menggambarkan kebolehan mencetak garisan halus yang sesuai untuk kegunaan pencetakan elektronik, grafik dan bio-perubatan.

ABSTRACT

This research focuses on the study of ultra-fine solid lines printing by using Micro-flexographic machine which is combination of flexography and micro-contact printing technique. Flexography is one of the famous and high speed roll to roll printing techniques that are possible to create graphic and electronic device on variable substrates. Micro-contact printing is a low cost technique that usually uses for micro to nano scale image especially in fine solid lines image structure. Graphene is nano material that can be used as printing ink which usually uses in producing micro to nano scale electronic devices. Lanthanum is a rare earth metal that has potential in printing industry. The combination of both printing techniques is known as Micro-flexographic printing has been successfully produced the lowest fine solid lines width and gap. The new printing technique could print fine solid lines image below 10 μm on biaxially oriented polypropylene (BOPP) substrate by using graphene as printing ink. The Micro-flexographic printing technique has been successfully printed fine solid lines with 2.6 μm width. This study also elaborates the imprint lithography process in achieving micro down to nano fine solid lines structure below 10 μm. In an additional, the lanthanum target has been successful printed on variable substrates with good surface adhesion property. This research illustrates the ultra-fine solid lines printing capability for the application of printing electronic, graphic and bio-medical.

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LIST OF SYMBOLS AND ABBREVIATION

PDMS	-	Polydimethylsiloxane
OFET	-	Organic Field Effect Transistor
OLED	-	Organic Light Emitting Diode
IC	-	Integrated Circuit
RFID	-	Radio Frequency Identification
SAM	-	Self-Assembled Monolayer
SFIL	-	Step and Flash Imprint Lithography
Py-GC/MS	-	Pyrolysis Gas Chromatography and Mass Spectrometry
µm	-	Micrometer
nm	-	Nanometer
UV	-	Ultraviolet Light
ITO	-	Indium Tin Oxide
PET	-	Polyethylene Terephthalate
FET	-	Field-Effect Transistor
IZO	-	Indium Zinc Oxide
P3HT:PCBM	-	poly(3-hexylthiophene):(6,6)-phenyl-C61-butyric acid methyl ester
h	-	Total Displacement
t	-	Time
h_e	-	Indentation Depth At The Spring
h_1	-	Indentation Depth at the Kelvin unit
τ_1	-	Retardation Time for the Kelvin unit
μ_0	-	A Constant Related to the Viscosity Coefficient of the Dashpot
a	-	Half-Contact Width

R	-	Cylinder Radius
b	-	Blanket Thickness
V	-	Velocity
F	-	Nip Load per Unit Length
fpm	-	Feet per Minutes
CO_2	-	Carbon Dioxide
YAG	-	Yttrium Aluminum Garnet
cpi	-	Cells per Linear Inch
F_a	-	Anilox Force
F_p	-	Print Force
TGA	-	Thermal Gravimetric Analysis
DSC	-	Differential Scanning Calorimetry
GO	-	Graphene Oxide
IPGE	-	Inkjet Printer Graphene Electrode
SEM	-	Scanning Electron Microscope
D	-	One Dimension
2D	-	Two-Dimensional
3D	-	Three Dimension
Si	-	Silicon
SiO_2	-	Silicon Dioxide
Nm^{-1}	-	Newton per Meter
CNT	-	Carbon Nanotube
La	-	Lanthanum
LNO	-	Lanthanum Nickelate
IT-SOFC	-	Intermediate Temperature Solid Oxide Fuel Cell
AC	-	Alternating Current
DC	-	Direct Current
ASR	-	Area Specific Resistance
CGO	-	Cerium Gadolinium Oxide
LSAM	-	Lanthanum Strontium Aluminum Manganite
YTZP	-	Yttria-Stabilized Tetragonal Zirconia Polycrystals
La_2O_3	-	Lanthanum Oxide
$La(OH)_3$	-	Lanthanum Hydroxide

LTCC	-	Low Temperature Cofired Ceramic
PP	-	Polypropylene
PE	-	Polyethylene
OPP	-	Orient Polypropylene
PCB	-	Print Circuit Board
PLA	-	Polylactic Acid
BOPP	-	Biaxially Oriented Polypropylene
°C	-	Degree Celsius
Tg	-	Glass Transition Temperature
Θ	-	Contact Angle
γ^{sl}	-	Solid/Liquid Interfacial Free Energy
γ^{sv}	-	Solid Interfacial Free Energy
γ^{lv}	-	Liquid Interfacial Free Energy
R2R	-	Roll to Roll
µCP	-	Micro-contact Printing
MPa	-	Mega Pascal
AFM	-	Atomic Force Microscopy
MPTES	-	Mercaptopropyltriethoxysilane
PVA	-	Polyvinyl Alcohol
PAA	-	Poly-Acrylic-Acid
PTBA	-	Poly-Tert-Butyl-Acrylate
RIE	-	Reactive Ion Etching
NIL	-	Nanoimprint Lithography
Ω	-	Ohm
LED	-	Light-Emitting Diode
N	-	Nitrogen
XRD	-	X-ray Diffraction
XPS	-	X-ray Photoelectron Spectroscopy
ARXPS	-	Angle Resolve X-Ray Photoelectron Spectroscopy
O	-	Oxygen
eV	-	Electron Volt
m	-	Metre
cm	-	Centimetre

mm	-	Millimetre
DB	-	Double Print
SP	-	Single Print
PDE	-	Partial Differential Equation
POF	-	Polymer Optical Fiber
N	-	Nickel
AFM	-	Atomic Force Machine
LCD TV	-	Liquid Crystal Display Television
CAD	-	Computer Aided Design
DVD	-	Digital Versatile Disc
IPGE	-	Inkjet Prints Graphene Electrode
GTAW	-	Gas Tungsten Arc Welding
$La_2(CO_3)_3$	-	Lanthanum Carbonate
ABS	-	Acrylonitrile Butadiene Styrene
LAS	-	Leica Application Suite
FDM	-	Fused Deposition Modeling Printing
FAT	-	Fixed Analyser Transmission
RF	-	Radio Frequency
Ar	-	Argon
BOM	-	Bill of Material
rpm	-	Revolutions per Minute
CD	-	Critical Dimension
lbs	-	Pound
m/hr	-	Metre per Hour
OH^-	-	Hydroxide
SiC	-	Silicon Carbon
N	-	Newton

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